Orientation of the Bivalve *Anadara trapezia* (Deshayes) Relative to Water Currents

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(1 Text figure)

INTRODUCTION

Although reports on the orientation of birds and the analyses of such orientation are extensive (Batschelet, 1965), while the orientation of palmate algae, gorgonians, barnacles, gastropod molluscs and fish to water currents is documented (Charles, 1961; Dinamani, 1964; Overholser, 1964; Theodor & Denizol, 1965; Weaver, 1963), few records are available on the orientation of bivalve molluscs to water currents (Morton, 1962). During a study on the ecological genetics of *Anadara trapezia* (Deshayes, 1840) (Nicol & O'Gower, 1967; O'Gower & Nicol, 1968) a correlation was noted between the orientation of this relatively immobile bivalve mollusc and the strength and direction of flow of water currents in the environment.

METHODS

Using the hinge line of the bivalve as the origin, the angular orientation of samples of 100 individuals was measured in 15° sectors with an underwater compass. The animals were systematically sampled from populations in restricted, circumscribed areas within the four selected localities, and the rate of water flow was measured at each site by timing a float past two markers. The four localities were selected on the basis of their current flow patterns, as follows:

1. **Mallacoota Inlet:**
   The sampling site was a sand flat at the edge of the channel connecting the small coastal lake to the Pacific Ocean, hence, although the site was exposed to a semi-diurnal mixed tide, under conditions of heavy rain there was a seawards flow of brackish water over several tidal periods.
2. **Gunnamatta Bay,** a northern inlet off Port Hacking:
   The sampling site was exposed to a semi-diurnal mixed tide, but with heavy coastal surfs small wavelets run from south to north, being either: deflected, north east swells; or direct, wind generated southerly waves.
3. **Smith's Lake,** a small coastal lake which is opened to the sea at irregular intervals to relieve flooding:
   Sampling site A was a sand spit where the summer, wind-induced, current flow was from the north east and the winter, wind-induced current was from the south west. Sampling site B was a small, island-sheltered bay lacking current flow.

The significance of the orientations was determined using the Chi-square test as a goodness-of-fit to a circular distribution (k, the number of groups, being 12, Batschelet, 1965).

To determine whether orientation was fortuitous or in response to current flow, 30 *Anadara trapezia* were placed in each of two closed aquaria for a five day period. One of the aquaria lacked any current flow, the other had a circular, anticlockwise current flow.

RESULTS

The compass bearing orientations of samples of *Anadara trapezia* are presented as polar wedge diagrams (Gum-

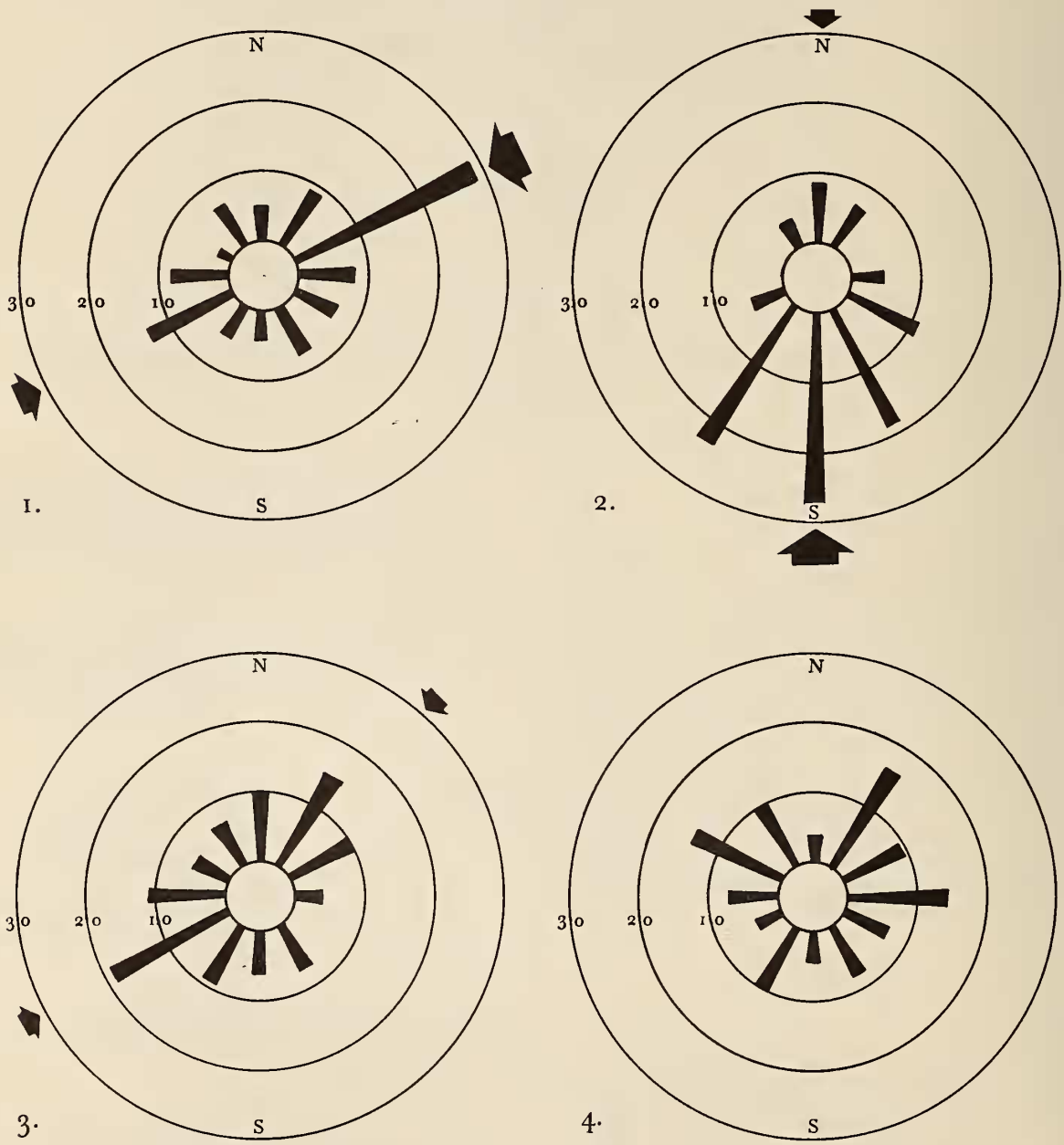

Figure 1

Angular orientation of *Anadara trapezia* from four localities:

1. Mallacoota Inlet 2. Gunnamatta Bay 3. Smith's Lake A 4. Smith's Lake B

Current directions are indicated by arrows, whose size indicate the relative volumes of water involved.

Table 1

Compass quadrant orientation of *Anadara trapezia,* percentages of animals lying on their sides, maximum rate and direction of water current and Chi-square value (n = 12) and probability for randomness of orientation of samples from four selected localities

Locality	Current		Side	Orientation						
	Rate (ft/min)	Direction	%	N-E	E-S	S-W	W-N	Total	X^2	P
Mallacoota Inlet Victoria	54.5	N. E. – W. S. W.	0	45	17	26	13	101	59.75	< 0.001
Gunnamatta Bay New South Wales	26.6	N. – S.	2	11	57	26	6	100	120.08	< 0.001
Smith's Lake A New South Wales	5.4	N. E. – W. S. W.	10	27	13	38	21	99	31.55	< 0.001
Smith's Lake B New South Wales	–	–	36	37	19	21	28	105	19.23	< 0.05

BEL *et al.,* 1953) in Figure 1 and the numbers of animals orientated in each of the compass quadrants and the maximum rate and direction of current flow for each of the four selected localities are given in Table 1. It will be noted that using the Chi-square test on the data in Figure 1 orientation was random for only one locality, Smith's Lake, Area B and that with decrease in current flow, there was an increase in the percentage of animals lying on their sides (Table 1) rather than half buried in the substratum.

In the aquarium lacking water currents 21.2% of the animals moved, but orientation was random. In the aquarium with a circular water current of approximately 30 cm/sec, 87.2% of the animals moved and 56.4% orientated in the direction of the current flow.

DISCUSSION

As *Anadara trapezia* is relatively immobile and cannot rapidly flush water across its gills, as it actively orientates into water currents (see Results, above), and as there is a positive relationship between the strengths and directions of water currents and the orientation of this mollusc in its natural environment (Table 1), it is probable that correct orientation would assist respiration, feeding and sanitation, while at the same time such orientation should lessen the chances of accidental dislodgment. The former hypothesis is an interesting challenge, while to support the latter hypothesis, it has been observed that *A. trapezia* suffers heavy mortalities in certain localities due to stranding, after the molluscs have been dislodged from the substratum by the action of wind-generated waves on the algae which have grown on their shells.

It is most unlikely that the latitudinal cline in haemoglobin polymorphism of *Anadara trapezia* (O'GOWER & NICOL, 1968) is correlated with either accidental dislodgment or orientation for respiration, feeding or sanitation; however, it is likely that accidental dislodgment strongly influences the abundance of this mollusc in certain localities, while correct orientation for respiration, feeding or sanitation should effect considerable savings in the expenditure of energy in these functions. The sensory mechanisms used by bivalves to detect such water currents obviously differ from those used by more active animals (WEAVER, 1963), but how such mechanisms operate with *A. trapezia* is at present unknown, and such a problem is worthy of further investigation. It seems probable that, unlike other active bivalves (MORTON, 1960, 1962), behaviour to currents will not involve visual stimuli but could involve tactile and gravity stimuli.

SUMMARY

The orientation of the bivalve *Anadara trapezia* (DESHAYES, 1840) is correlated with the direction and strength of tidal or wind-driven water currents both in the natural environment and under experimental conditions. Such orientation is probably associated with survival and with various physiological functions.

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